

Stapes Mobilization for Otosclerotic Deafness

The Monitored Peribasal Technique

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"CLINICAL OTOSCLEROSIS" is the most common cause of deafness in adults. Histologically, the lesion is bony dystrophy originating in the labyrinthine capsule. Starting as "otospongiosis" it matures into "otosclerosis." In its most common form, the lesion invades the anterior limb of the stapes footplate and the medial aspect of the anterior stapedial crus. This bony bridge produces a mechanical obstruction to normal transmission of acoustic energy to the vestibular perilymph. The impedance matching effect of the middle ear mechanism is thus lost and "conductive deafness" ensues. The basic cause of otosclerosis remains obscure, and there is no known method of prevention or of medical therapy.

The symptoms of otosclerosis are deafness, tinnitus, and occasionally vertigo. The onset is insidious, usually bilateral, and slow in rate of progression. It is more common in females. It starts in the second or third decade of life and usually reaches a stable plateau in the fourth or fifth decade. Usually no abnormalities can be seen otoscopically. The canal, drum, middle ear and eustachian tube are normal. Results of tuning fork tests and audiometric examination are typical of conduction deafness. The result of the Rinne test is negative, bone conduction (BC) of sound being greater than air conduction (AC), and there is a significant bone-air gap* on pure tone audiometry. Vertigo occurs in occasional cases but is not usually severe; it may resemble that of Meniere's disease.

The surgical approach to this problem had its origin in 1876 with the observation by Kessel⁷ that manipulation of the stapes could improve the hearing in stapes ankylosis. Further surgical intervention by Miot⁹ in 1892 showed that this idea was practical. However, for various reasons this surgical method was temporarily dropped. It was not until several decades later that an indirect or detour surgical route through the vestibular labyrinth was devised, and it was finally perfected by Lempert⁸ in 1938.

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*The bone-air gap is the expression in decibels of the degree of conductive deafness.

• Direct surgical operation on the stapes footplate region in the treatment of hearing loss due to otosclerosis has been revived.

In the last 100 cases of a total series of 600, the peribasal stapes mobilization (stapedolysis) technique was completely successful in 62 per cent, partially successful in 29 per cent and a failure in 9 per cent.

Stapes mobilization requires precise microsurgical technique monitored by audiometry during the surgical procedure.

It appears that mobilization is the preferred approach to the surgical treatment of otosclerosis, but fenestration of the vestibular labyrinth is an important secondary procedure in some cases.

Successful restoration of hearing requires adequate mobility of the footplate coupled with physiological continuity of the drum ossicular chain mechanism.

In 1952, Rosen¹⁰ revived interest in the direct surgical attack on the stapes itself. Since then the direct operation has been shown effective in a large number, perhaps a majority, of patients with otosclerotic deafness.

In view of experiences of the past few years, stapes mobilization, the direct operation, appears to be the preferred primary surgical treatment for otosclerotic deafness. Fenestration of the horizontal semi-circular canal now takes a secondary but very important position in the surgical plan. The otosclerotic patient deserves a total approach to the problem of surgical management. Ideally, the surgeon who undertakes the stapes mobilization procedure should be prepared by training and experience to subsequently perform a fenestration operation if necessary.

As has been pointed out in previous publications, physiologically the stapes mobilization (stapedolysis) approach is preferable. It is a direct operation upon the mechanical lesion and does not destroy the efficacy of the normal middle ear mechanism. It not only is of great value in patients with moderate losses who can hope for restoration of normal hearing, but is of great value in patients with far advanced disease with secondary cochlear involvement who cannot hope for normal hearing but may hope

for a significant improvement which will permit better utilization of amplification through a hearing aid. The operation can be done on patients of almost any age, and the morbidity factor is very low. It is, however, a precise and highly intricate anatomical procedure which requires dextrous micro-surgical technique.

The fenestration operation, on the other hand, is a detour procedure which is of great value in cases of irreversible ankylosis not amenable to stapes mobilization techniques. Since the surgical approach necessitates removal of the incus and the head of the malleus, the impedance matching action of the middle ear is usually lost, and the gain in hearing is not as great as that which can be expected in stapes mobilization. Nevertheless, in properly selected cases, it will improve the hearing threshold* to at least a 30-decibel level or better, which is adequate for the hearing of speech in most situations.

In general, any patient who has clinical otosclerosis with an adequate bone-air gap and a bone conduction level not lower than 45 decibels, may be considered a candidate for stapes mobilization. There are no age restrictions, and since the procedure is done under local anesthesia with very little surgical trauma, there are no major contra-indications medically.

There has been a significant evolution in the modus operandi of stapes mobilization since the first publication of Rosen⁴ when he advised mobilization via the stapedial neck with a specially curved instrument. Shortly thereafter, other investigators² suggested application of force through the lenticular process of the incus, through the capitulum of the stapes, and other modifications in the region of the incudostapedial joint. It was quite logical that attempts to mobilize the ankylosed stapedial footplate should begin at the incudostapedial joint, because of its anatomic accessibility and the possibility of transmitting force through the stable crura. However, it was noted that incudostapedial dislocations (Figure 1) could be troublesome, and that crural (Figure 2) fractures could be severe problems. In a large number of cases, force applied to the joint itself could give a sensation of mobilization which in fact was mobility due to crural trauma. In such cases the stapedial footplate remained ankylosed even though the stapes seemed to be mobile on digital palpation. This approach, coupled with nonquantitative, nonaudiometric evaluation of adequacy of the surgical procedure, was at fault in many failures.

Through the recognition of the importance of quantitative measurements, and the utilization of a mathematical formulation of surgical physiology

*The hearing threshold is the least intensity of sound, in decibels, that the patient can hear.

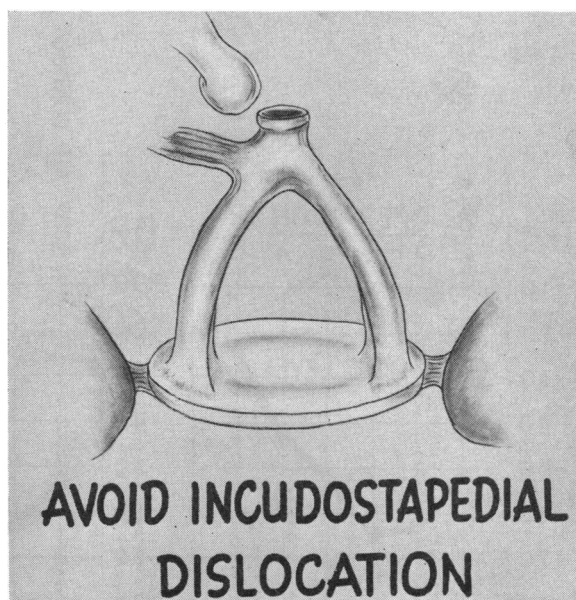


Figure 1

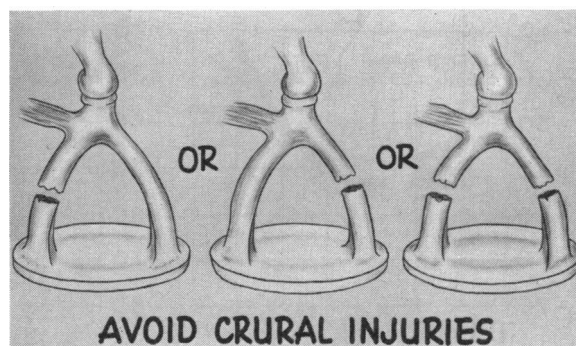


Figure 2

through the "audiometric nomograph"³ technique, some of the dangers that were due to inadequacies in surgical manipulation were pointed out. Recognition of these inadequacies coupled with better magnification and illumination of the fossa ovalis and stapedial crura, logically turned the attention of otologic surgeons to the footplate region.

Methods of operative treatment of the footplate have been quite varied—of direct fractures, incisions, applications of hammer force, fenestration and peripheral curettage of the footplate region. Each of these procedures has its advocates who ascribe special merit to one or another technique. In all of these footplate approaches, there has been one area of agreement—namely, that preliminary operative results are greatly improved in numbers and in the degree of improvement in hearing.

I have previously stated^{4,5,6} that the purpose of stapes mobilization should be lysis of the ankylosed stapedial footplate in such a manner that the entire footplate or a movable fragment will be in con-

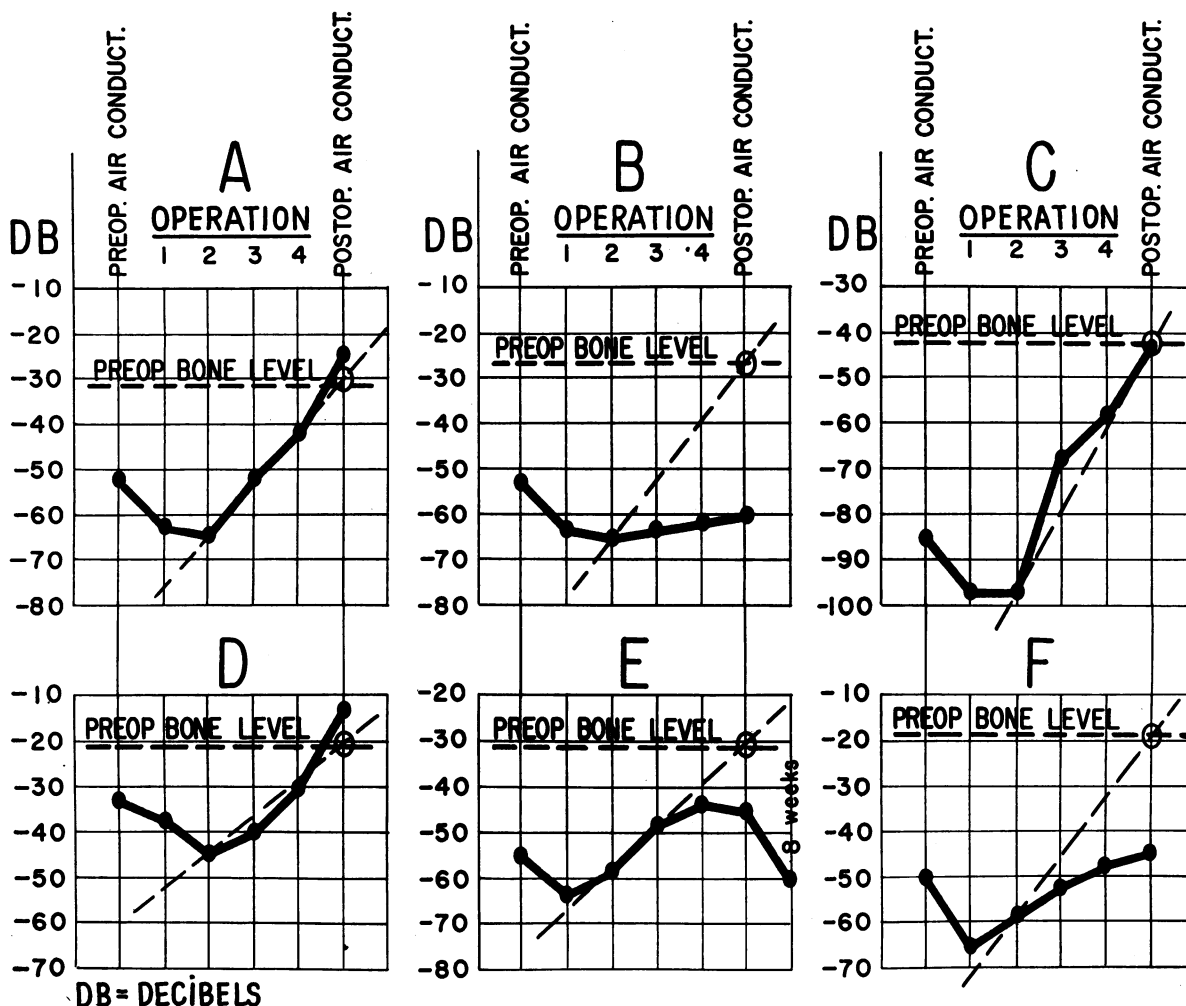


Chart 1.—Examples of results of audiometric testing from time to time during operation. The diagonal interrupted line represents the preoperative prediction. The horizontal numbers 1, 2, 3 and 4 represent various stages during the operation at which audiometric "sampling" was done to inform the surgeon how near or far he was from the desired effect. The charted results are examples of:

A, adequate stapes mobilization. Note that the dark line—showing the progress—conforms closely to the line of prediction.

B, failure to mobilize. Note that the progression line does not rise with the line of prediction.

C, adequate mobilization in a case of wide bone-air gap.

D, adequate mobilization in a case in which the bone-air gap was narrow.

E, adequate mobilization followed by early re-ankylosis of the footplate and loss of initial gain in hearing.

F, inadequate mobilization. Note that progression line shows a gain in hearing but does not conform to the predicted gain as represented by the interrupted diagonal line.

tact with the intact mobile ossicular chain, either through one or both stapedial crura, resulting therefore in either a monopod or bipod stapedolysis. This physiological objective remains a necessity.

In order to monitor the progress of applications of force to the stapediostibular lesion, some method of physiological guidance appeared necessary. Since visual and digital information did not suffice for this purpose, the only method that could be relied upon was a "titration" based upon thresh-

old changes as determined by audiometric studies carried out during operation.

Stapedolysis is not an all-or-none operation. True, an all-or-none approach will yield a certain number of successful results simply because of the nature of forces and resistances encountered, but a large number of failures resulted from the application of the all-or-none principle. The ossicular chain will not stand for all-or-none application of force, as is evidenced by the large number of crural fractures

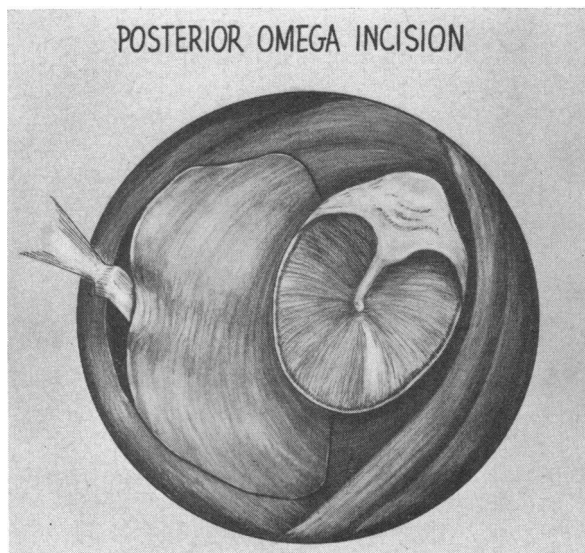


Figure 3

and incudostapedial disarticulations reported by several investigators.

Methodical degree by degree transmission of force sufficient to produce maximum lysis and yet insufficient to disrupt the middle ear mechanism is obviously a desideratum. This guided and titrated application of force cannot be based upon simple physical measurements of the amount of force applied. Serial determinations of the hearing threshold, using audiometry during operation, are required.

It was recognized some time ago that such serial measurements must be evaluated in each case on the basis of a ratio formulated from the bone-air gap. This led to the development of the nomograph technique, which has been described in several publications previously.^{3,4} The nomograph, a graph constructed according to a mathematical rule, allows the plotting of progression of the surgical procedure on the operating table and offers the otologic surgeon precise guidance as to the adequacy of lysis. It also indicates ossicular discontinuity, inadvertent foot-plate fenestration, round window lesions, and inadequate lysis. By using an averaging technique developed by Fletcher,¹ the Fletcher formula gives us a single figure of merit for speech reception threshold which we call the *equivalent SRT*, and this single figure of merit allows for convenient mathematical comparisons. Chart 1 illustrates typical nomographic studies in a variety of conditions encountered surgically.

A monitored peribasal technique as used at present may be described as follows:

Premedication. Simple barbiturate premedication is adequate in most cases and the exact dosage is dependent upon the age, weight and general condition of the patient. Opiates are not generally used.

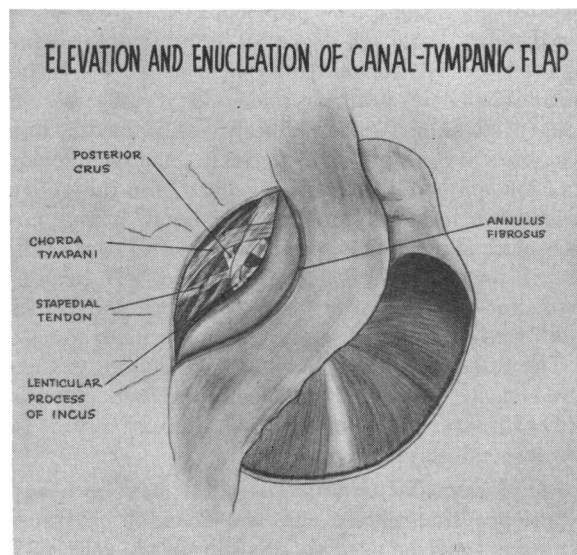


Figure 4

It is desirable that the patient be calm and relaxed but not so sleepy that accurate audiometric studies will not be possible.

Skin Preparation. Routine surgical skin preparation is used after the hair has been carefully draped and covered by a stockinet cap. Aqueous Zephiran® (benzalkonium) is used in a 1:1000 solution within the canal for purposes of antisepsis and production of drum edema to allow easier enucleation and elevation of the canal tympanic flap.

Anesthesia. The cutaneous lining of the bony canal wall is adequately anesthetized by blocking with 2 per cent Xylocaine® (lidocaine) with epinephrine 1:20,000.

Incision and Elevation of the Canal Tympanic Flap. The procedure is performed through ear specula of various sizes. Illumination and magnification must be precise and are usually obtained through headlight-loupe combinations.

An angulated circumferential scalpel is used to create a fairly large posterior omega-shaped incision as illustrated in Figure 3. This skin periosteal flap is dissected down to the tympanic annulus and the drum insertion is elevated from the bony annulus so that the middle ear is exposed in its posterior one third (Figure 4). Sufficient bone is removed from the annular margin (Figure 5) to allow for adequate exposure of the lenticular process of the incus, the stapes, the chorda tympani, the stapedial tendon, the crura, the promontory and the round window niche. All of these structures must be visualized before surgical approaches can be made safely.

Palpation of Incus. The incus is gently tested for mobility (Figure 6) by palpation with a fine angulated needle probe engaged within the lenticular

periosteum. Even in the presence of a rigidly ankylosed stapes, there is a degree of mobility of the incus which is easily determined by such palpation. If the incudomalleolar joint is fixed, as it may be, in congenital anomalies or adhesive otitis media, this diagnosis is all-important. Such incudomalleolar fixation may well account, by itself, for the entire conductive loss; or, on the other hand, it may co-exist with stapediovestibular fixation and cause failure if its presence is not recognized. (If incudomalleolar joint fixation is recognized, the stapes mobilization approach alone is usually inadequate.)

The integrity of the incudostapedial joint is then assessed by palpation. A loose joint will call for extraordinary care in manipulation in order to avoid incudostapedial dislocation.

Incudostapedial Manipulation. It has been my experience that rarely can transincudal or transcapitular force be used successfully in the relatively early or mild ankylotic states. It is not possible to tell, on the basis of the hearing threshold, the age of the patient or the duration of the disease whether there is only mild ankylosis. However, in many cases of the less mature forms of the disease, the ankylosis may be confined to the anterior limb of the footplate, or occasionally to the posterior limb alone. In such instances, safe lysis may be possible by force applied to the entire ossicular chain by way of the lenticular process or the capitulum. The former is preferable, since it has a slightly lesser tendency to dislocate the joint. However, if the joint is loose to begin with, it is preferable to use force on the capitulum.

The digital force used must be firm but gentle, and while force is being applied the entire ossicular chain must be observed as a *total mechanism* with special attention to the footplate region. In most successful cases there will be a general loosening and the stapes will usually be displaced slightly in a posterior direction. When effective displacement appears to have occurred, an audiometric test with nomograph guidance is obtained. Such alternations of application of force and audiometric tests are used until a decision is reached that the optimum result has been attained.

Peribasal Technique. In most instances, the approach I use is directly to the peribasal region, and not to the footplate per se. The first step is a careful survey of the footplate and contiguous areas. If such a study reveals, for example, an advanced invasion of the anterior crus and anterior limb of the footplate by the otosclerotic process, attempts at bipodal (two-legged) lysis are almost certainly doomed to failure. In such a case, the only hope of success is in monopodal (one-legged) lysis with anterior crurotomy. If, on the other hand, inspection reveals normal integrity of both crura but invasion of the

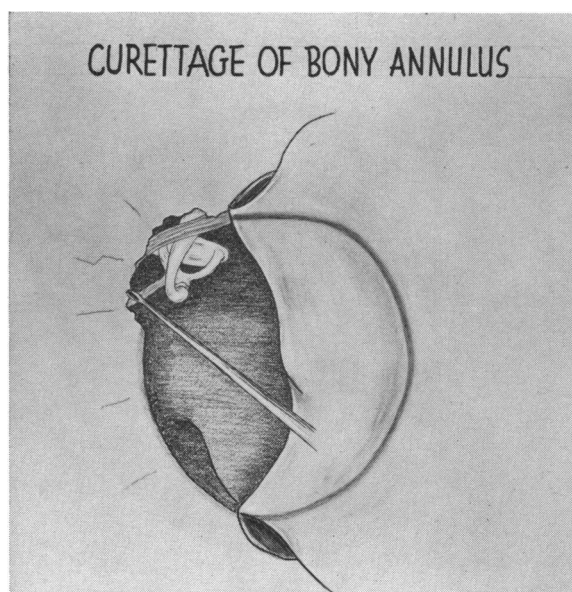


Figure 5

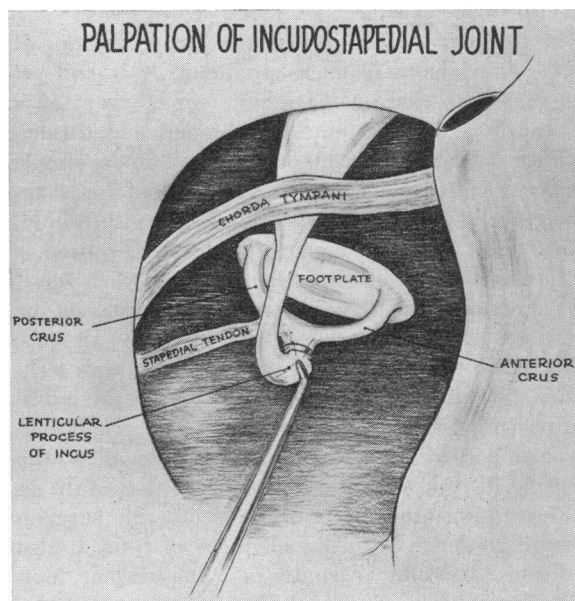


Figure 6

footplate and ligament by otosclerotic bone, *peribasal* use of a needle probe can be highly successful and result in preservation of the anatomic continuity of both crura (bipodal with a mobile footplate)—a normal, and thus desirable, physiologic state. To achieve careful footplate lysis with attention to the foregoing physiologic principles, force can be applied digitally with needle probes of varying sizes and angles, and tiny chisels. Such instruments may also be used in severe ankylosis problems, in conjunction with an electric hammer or microvibrator.

The survey of the footplate and contiguous area,

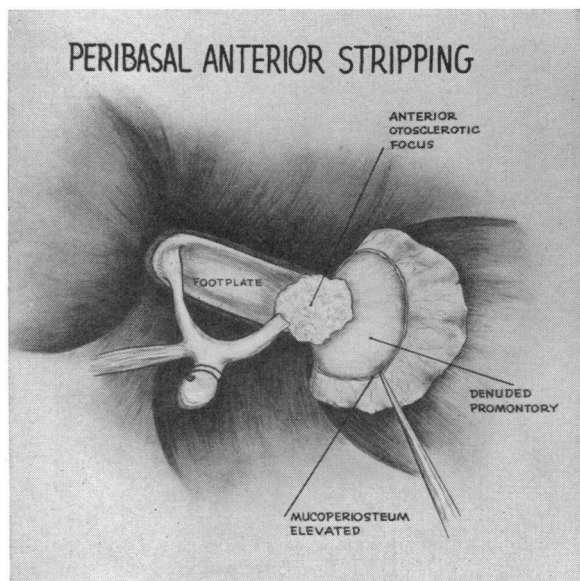


Figure 7

as referred to above, is frequently hampered by a pathologic thickening of the mucoperiosteum in the anterior crural area. Extensive otosclerotic invasion of the anterior crus, the anterior half of the footplate and the anterior aspect of the oval window niche will be accompanied by a thickening of mucoperiosteum in this area, making accurate viewing impossible. Consequently, it is necessary to strip the mucoperiosteum from this region as illustrated in Figure 7. With a small needle probe or a tiny curet, a small incision is made in the mucoperiosteum along the inferior margin of the footplate region and extending anterior to the anterior crus. This mucoperiosteal incision is carried down to the promontory bone, and the mucoperiosteum is reflected anteriorly and inferiorly away from the oval window niche. Frequently this will permit a surprisingly good view of the gross otosclerotic lesion and will enable more precise application of instruments to the peribasal region.

In using the peribasal technique to attempt bipodal lysis, it is desirable to insert the needle probe (Figure 7) first immediately anterior to the anterior crus and toward the vestibule through the region normally occupied by the annular ligament, which is frequently replaced by pathologic bony growth (Figure 8). If the disease is limited to the anterior limb, this maneuver alone may be adequate to produce lysis.

If adequate lysis is not demonstrated visually and confirmed nomographically the same procedure is carried out in a similar position posterior to the posterior crus, again through the region of the annular ligament, since in such cases there will be a lesion posteriorly as well as anteriorly (Figure 9).

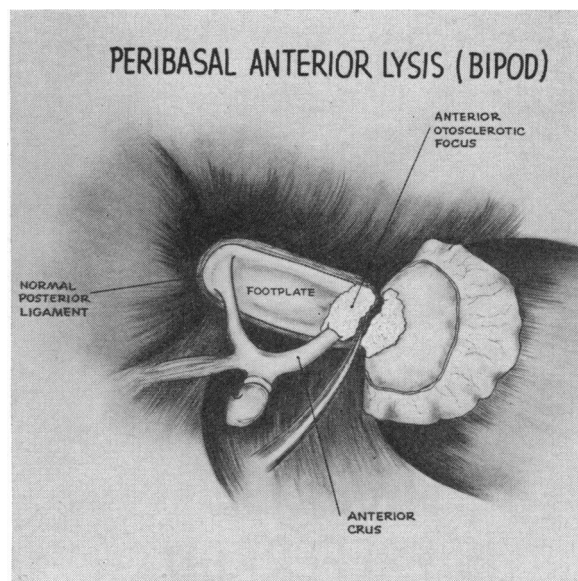


Figure 8

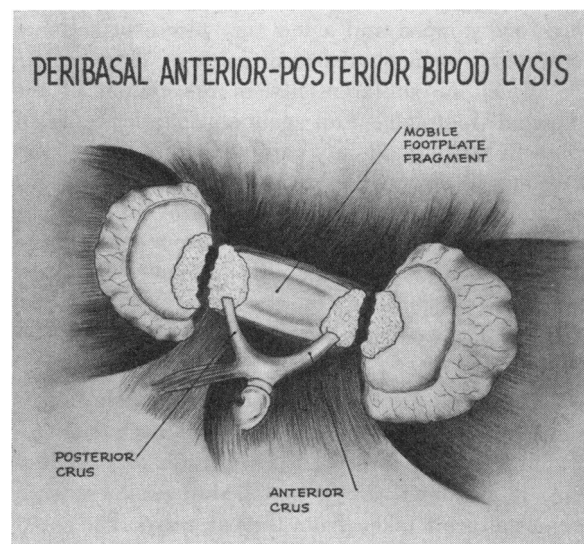


Figure 9

In general, bipodal lysis (Figure 10) as described above, seems more successful than monopodal lysis. This is to be expected because of the more advanced degree of disease in the cases in which monopodal lysis is done. Nevertheless, monopodal lysis has brought about satisfactory salvage of hearing in enough cases to justify use of the technique where necessary (Figure 11).

Direct fenestration of the footplate itself has been advocated by some investigators, but it appears to be an unphysiological procedure and I have not obtained satisfactory results with it.

When nomographic studies indicate adequate lysis of the ankylosis with preservation of ossicular and drum membrane continuity, applications of

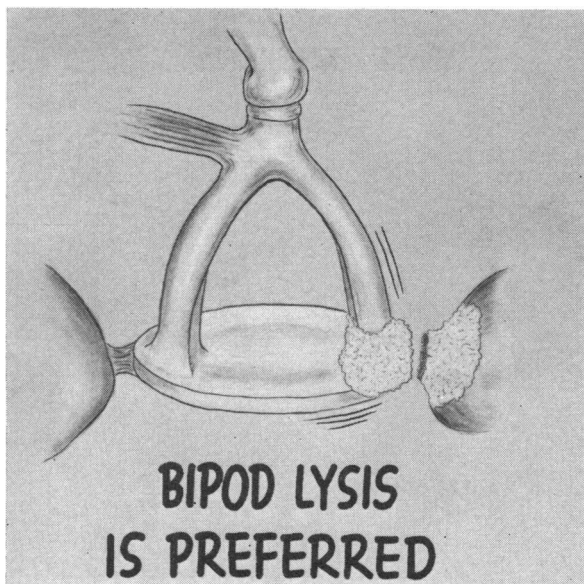


Figure 10

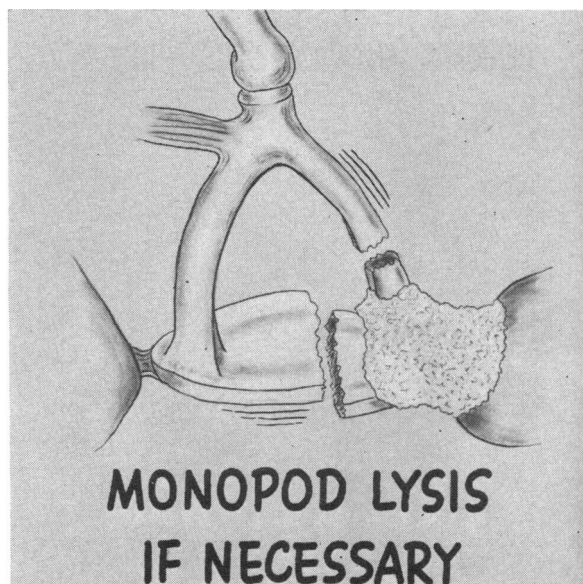


Figure 11

force are stopped and a few tiny pieces of gelfoam saturated with neohydeltrasol solution (Figure 12) are placed circumferentially in the region of the stapedia footplate. This gelfoam barricade is of value in sealing off any minute labyrinthine fractures and in protecting the perilymph space from the full impact of transtympanic airborne sound. Tests then made by surgical audiometry are more likely to be reliable and the possibility of spurious direct acoustic transmission to the perilymph can be avoided. The neohydeltrasol solution has caused no undue reactions.

Closure and Packing. The canal tympanic flap is gently replaced and carefully moved back into position. If there has been a perforation or marginal tear, it is closed by a small, full-thickness skin periosteal graft taken from the ear canal. The canal tympanic flap is covered with four or five rayon strips saturated in normal saline solution, and a few cellulose sponge pledgets saturated with cortisone ointment are placed within the canal to exert gentle pressure on the rayon gauze and on the canal tympanic flap. Such packing appears advantageous in preventing undue postoperative capillary oozing and in keeping adequate tension on the drum so that it heals with normal physiologic restoration. The ear canal is filled with cotton and a mastoid dressing applied for one day.

Postoperative Care. The patient remains in the hospital overnight, and is usually discharged the following morning unless there is unusual vertigo, which occasionally occurs. Antibiotic therapy is used on all patients, and a broad-spectrum drug is usually chosen after careful inquiry as to previous



Figure 12

history of drug sensitization. Such prophylactic therapy is continued for five to seven days.

Vertigo occurs in about 30 per cent of patients. Usually it is utricular in nature. In most cases it is abated by giving dimenhydrinate (Dramamine®), and usually it is self-limited. In general, vertigo is less of a problem with stapes mobilization than it is in fenestration operations.

The packing is usually removed on the sixth day, following which no special measures are necessary. By that time, the skin has usually healed and edema of the drum is subsiding. The hearing usually is somewhat impaired by the packing but becomes more acute upon removal of the packing and then improves further in the ensuing week or two. De-

layed shifts in the hearing threshold may occur in some cases due to hemorrhage or temporary interferences with the coupling mechanism of the ossicular chain.

Complications. No serious complications occurred in almost 700 cases. Tympanic perforation occurred in two instances. In a few cases loss of hearing increased after operation, owing to reankylosis, but there were no cases of cochlear destruction. Two patients had persistent mild utricular vertigo.

Reankylosis. Since the surgical operation is directed to the otosclerotic lesion per se, it would be expected that osseous regeneration would produce reankylosis. This does occur in some cases, sometimes soon after operation, sometimes after a considerable interval. The exact incidence of reankylosis cannot be stated at this early stage in the use of the stapes mobilization operation, but it does not appear to be higher than closure of the fenestra in fenestration. It probably develops in not more than 15 per cent of cases in which the operation is at first successful.

Reoperation is merited in cases of reankylosis. In the series here reported upon, successful results were obtained in the revisionary operations about as often as in the primary procedures. If, however, reankylosis occurs again, further revision would be justified in selected cases only. In most such cases, fenestration is indicated.

Tinnitus. In my experience, the tinnitus associated with otosclerosis disappears in most cases of successful mobilization, and persists in cases in which the operation fails. There are, however, exceptions in both categories.

Binaural Stapedolysis. Since speech audiometric studies have shown that discrimination (intelligibility) scores are considerably higher when hearing is binaural, and since binaural hearing also makes possible directional acoustic perception, it seems advisable to do binaural mobilization wherever possible. Not always, however, is the result in the contralateral ear the same as that obtained in the first ear operated upon.

Perspectives.

A. Recently this procedure has been extended to patients who do not have normal tympanic membranes by combining stapes mobilization with myringoplasty in a one-stage operation. The specific technique has been reported elsewhere.⁶

B. A conductive efficiency evaluation concept has recently been proposed by A. L. Holcomb, my research colleague, who suggests the utilization of the formula derived by dividing the bone-air gap into the decibel gain. The resulting percentage gives a reasonable measure of the conductive efficiency in restoring impedance-matching function to the mid-

dle ear or in removal of the conductive block.

Results. Postoperative results have been reported in great detail in previous papers.^{4,5} The results reported are determined by appraisal of the first tests carried out approximately two weeks after operation. The terms here employed are the same as those used in previous reports, and may be defined as follows:

A. "**Thresholds.**" The values of acoustic threshold are stated in terms of the equivalent speech reception threshold derived from the Fletcher formula.* Thus, since audiometric measurements vary in 5-decibel steps, the equivalent S.R.T. values used here usually vary in 2.5-decibel steps.

B. "**No Change.**" The term *no change* is used to indicate a postoperative air conduction level that has not changed by more than 5 decibels, plus or minus, from the preoperative level.

C. "**Losses.**" If the air conduction level after operation is 7.5 decibels or more below the level before operation, the decrease is described as "loss."

D. "**Partial Gains.**" Partial gains are increases of 7.5 decibels or more in air conduction perception, but less than those defined as success.

E. "**Success.**" Dual criteria must still be retained for success, since most other investigators who report on the subject are still using the fenestration criteria under which any postoperative level within 30 decibels of normal is considered successful. However, I am convinced that removal of the air conduction block (or elimination of the bone-air gap) should also be considered a "success" regardless of the final air conduction level. Since audiometric measurements are not considered accurate in measurements finer than 5 decibels, I arbitrarily assume this criterion: If air conduction after operation is not more than 7.5 decibels below preoperative bone conduction, the operation is considered successful. (In general the only confusion likely to occur from this dual definition of success lies in the region in which air conduction is between 30 and 40 decibels and bone conduction is near normal. Most of the successful cases, as judged by the 30 decibels standard only, lie in this area; and counting them as successful materially improves the results reported for such groups. Approximately 43 per cent of the successes reported qualify in both categories; the remainder are about equally divided between cases that qualify in one category only.)

In the first 500 cases in the series here reported upon, successful result as judged by our dual standard was obtained in 52 per cent of cases. In 43 per cent of cases, results qualified as successes in both categories. In approximately 24 per cent of the 500

*An average of the two best threshold responses at 500, 1,000 and 2,000 cycles.

cases, results were eventually classed as failures for various reasons. In another 24 per cent, significant gains were obtained, varying from improvement of 7.5 decibels to as much as 40 decibels, although not qualifying as successes in either of the stated categories.

In the most recent group of 100 cases in a study of 600 cases, results were successful in 62 per cent; in 29 per cent significant but less than successful gains were obtained; and in 9 per cent the operation was a failure.

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Social Security Footnotes

THE GOVERNMENT, while slow to acknowledge anything wrong with the Social Security system, underestimated the demand for benefits. Women who could obtain benefits at 62, 63, and 64 decided to do so even if the payments were less than they would be at 65. Farmers suddenly turned out to be older than expected. Some began to pay social security taxes on reported income of \$4,200 which exceeded their income in prior years. Then they applied for benefits after paying taxes for six quarters. Many people who had retired and were well beyond 65 years of age, dug up jobs for themselves and paid social security taxes for 18 months, thereby qualifying for benefits of from \$30 to \$108.50 monthly for life. Social security experts in making their cost projections underestimated the ingeniousness of the American people when federal give-aways are as widely advertised as are social security benefits.

—From the Department of Public Relations, American Medical Association